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Lepidogalaxias salamandroides Mees — A Redescription, with Natural History Notes

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Abstract

Lepidogalaxias salamandroides Mees is redescribed, knowledge of its relationship reviewed, sexual dimorphism discussed, and specializations related to its habits and habitats reported. The eyes are adnate, lacking eye muscles and a curious ability to bend the head downwards and sideways is noted.

Introduction

The description in 1961 by Mees of a so-called 'scaled galaxiid', *Lepidogalaxias salamandroides*, revealed one of the most distinctive and enigmatic freshwater fish discovered in recent times. The fish itself is small and unspectacular. It reaches only about 70 mm, and is rather drab-coloured but is seemingly highly specialized. Although Mees (1961) included the species in the Galaxiidae, his view was (p. 33) 'that it seems impossible to place it in any of the extant genera of the Galaxiidae', suggesting it belongs 'perhaps even in a separate subfamily' (p. 38).

Superficial examination indicates that, apart from the dorsal fin being posteriorly placed, over the anal, there is little obvious cause to include the fish in the family Galaxiidae. More detailed study supports this view. McDowall (1969) in a review of Southern Hemisphere salmoniform freshwater families (Galaxiidae, Aplochitonidae, Retropinnidae, Prototroctidae) expressed the opinion that the 'odd little species *Lepidogalaxias salamandroides* is not a galaxiid'.

Frakenberg (1969: 108) concurred: '. . . *Lepidogalaxias* is clearly distinct not only from galaxiids but in certain respects from salmoniform fishes as a whole'. In Frankenberg's opinion (1968: 9; 1969: 108), the species belongs in a separate family Lepidogalaxiidae. Familial status was assigned by Rosen (1973: 483) without background comment, and reaffirmed by Rosen (1974: 311). Lake (1972) listed *Lepidogalaxias* in the Galaxiidae, as did Nelson (1976) who was aware of Rosen's view (1974), but Lake (1978) recognized Lepidogalaxiidae, as did Berra (1981) and Allen (1982).

The relationships of this fish are far from obvious. Frankenberg (1968) was the first to comment on these noting that *Lepidogalaxias* (p. 9) 'can in most respects be regarded as ancestral to the galaxiids . . . is at least as primitive as any living teleost, and among these, it serves to relate the galaxiids with the Northern Hemisphere esocoid fishes rather

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than with the salmonids.' Rosen (1974: 269) thought that 'A review of the anatomy of salmoniform gill arches, caudal skeleton, and secondary sexual characters suggests that *Lepidogalaxias* is an esocoid . . .' This view is somewhat astounding, because if correct, it means that *Lepidogalaxias* is the only representative of the sub-order Esocoidei in the Southern Hemisphere. Although acceptance of Rosen's view of the relationship is difficult no other plausible views have been offered. The implications for the evolution and biogeography of world freshwater fishes are profound, and yet the survival of a relict esocoid in south-western Australia really has no important biogeographical implications until a much clearer picture of relationships emerges.

Fink and Weitzman (1982) were dubious about the supposed esocoid relationship — 'Of the eleven characters Rosen (1974) used to place *Lepidogalaxias* in the Esocae, only four appear to be appropriate for inference of relationship . . . In view of the reductive nature of all of these characters and the very small size and benthic 'habits' of *Lepidogalaxias* and in view of the biogeographic hypothesis suggested by this hypothesis of relationships a further search for characters is warranted' (p. 81-82). *Lepidogalaxias* ranks, in Australia, with the dipnoan *Neoceratodus* as an ancient endemic whose occurrence in Australia 'is of interest primarily because of the survival of an ancient fish stock rather than for reasons of biogeography . . .' (McDowall 1981: 1257). Rosen (1974) believed that the esocoid relationship of *Lepidogalaxias* 'dates to the fragmentation of Pangaea'. Beyond this, (whatever the real relationships) little can be said about the zoogeography of this species; again its interest lies primarily in its survival (McDowall 1981: 1258).

Thus we have, in south-western Australia, this small fish, superficially unspectacular but highly specialized and belonging to an endemic monotypic family whose nearest relatives may be northern temperate esocoids, but which may also belong somewhere else amongst the most primitive of teleost fishes.

Since its initial, brief description, based on only 6 specimens 37-60 mm total length, little has been published. The only detailed observations are those of Rosen (1974) primarily on osteology and relationships, with some comment on sexual dimorphism in the structure of the anal fin.

The availability of additional material provides the opportunity for an expanded description and examination of sexual dimorphism. In addition observations on habitats occupied and better definition of the geographical area occupied become possible.

Study methods follow those of Hubbs and Lagler (1958), as outlined, and modified by McDowall and Frankenberg (1981).

Systematics

Genus *Lepidogalaxias* Mees, 1961

Type Species

Lepidogalaxias salamandroides Mees 1961: 33, by original designation.

***Lepidogalaxias salamandroides* Mees**

Figure 1

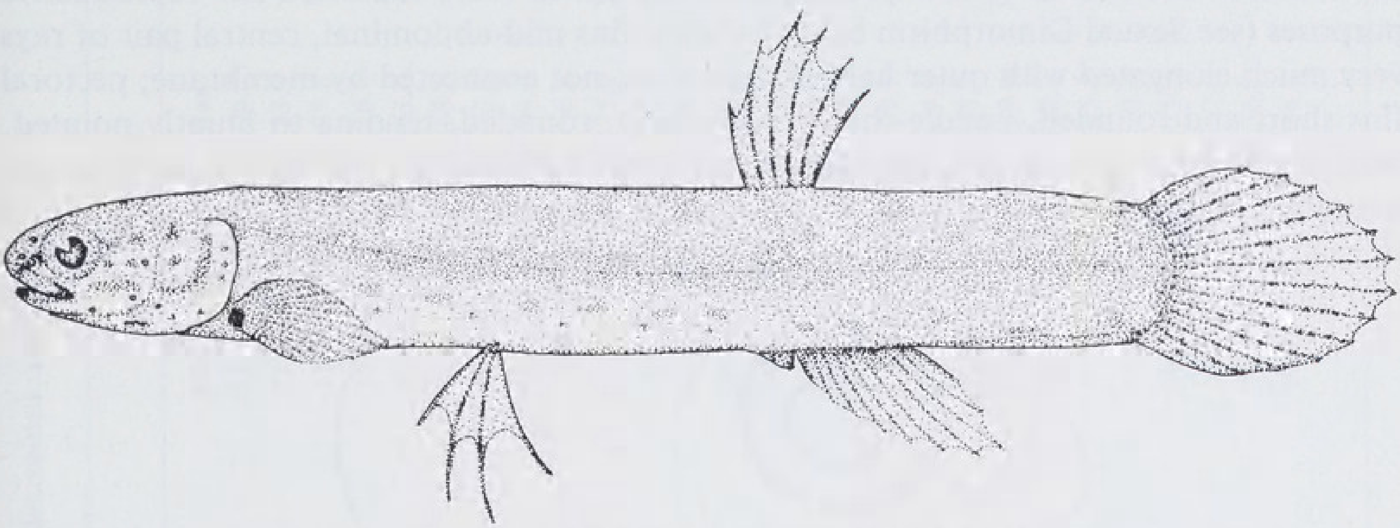

Figure 1 *Lepidogalaxias salamandroides* Mees; female, 70.5 mm TL Shannon River, W.A. (WAM P.27522-001).

Diagnosis

Characterized by elongate slender form; scales present, rudimentary, on lateral surfaces only; dorsal fin far back on trunk very short-based but high; abdominal pelvic fins with very long rays; orbits adnate; sexes different, male with enlarged anal fin sheathed with scales.

Description

Small, elongate and slender. Trunk tubular to slightly compressed, increasingly so towards tail, dorsal and ventral trunk profiles parallel from head to tail, tapering anteriorly to a blunt snout; caudal peduncle very long, deep, somewhat compressed, much longer than deep.

Head short, broad posteriorly but anteriorly is laterally compressed to form a narrow, beak-like snout, which is short and blunt. Mouth of moderate size, only slightly oblique, reaching back well below eyes, mouth terminal, jaws about equal. Eyes of moderate size, adnate, high on head, upper margin nearly level with upper head profile, interorbital flat, narrow. Nostrils simple apertures. Teeth in jaws uniserial, lacking enlarged canines, no teeth on tongue but a row of strong palatine-vomerine teeth in roof of mouth. (Mees 1961, calls the palatine teeth endopterygoidal). Gill rakers short and stout. Operculum free from isthmus, margin entire without spines.

Gut with a simple pouched stomach and a single intestinal loop, lacking pyloric caeca.

Scales present, cycloid, very thin, outer margin heavily invested in skin confined to lateral surfaces thus absent from back and belly, absent also from head, but present from opercular opening to tail base, about 65 in mid-lateral series; lateral line present, running along mid-lateral from opercular opening to tail base. Only laterosensory pores on head a row in preopercular series; rows of papillae as in Figure 2. All fins membranous; only one dorsal fin, positioned posteriorly on trunk above vent, very short-based but high, flag-like and pointed, third (middle) ray much the longest, none or few procurrent rays. Anal fin small, short-based and rounded, few procurrent rays, fin in male modified for reproductive purposes (see Sexual Dimorphism below). Pelvic fins mid-abdominal, central pair of rays very much elongated with outer half of these free, not connected by membrane; pectoral fins short and rounded, paddle-shaped. Tail long, rounded, tending to bluntly pointed, central rays much the longest, procurrent rays weakly developed, caudal peduncle flanges strongly developed.

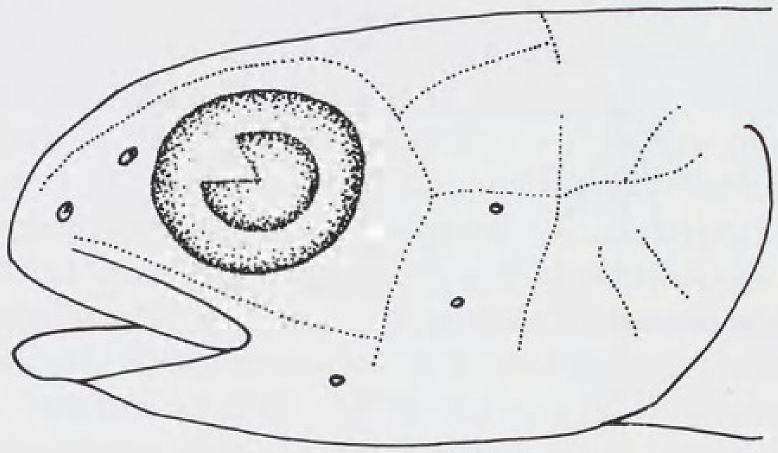

Figure 2 Disposition of laterosensory pores and papillae on head of *Lepidogalaxias*.

Colour of female: When alive brown to greenish-brown, with a series of brown-black saddle-like markings along back, a mid-lateral series of dark blotches, tending to form a pair of irregular longitudinal lines along the trunk, the lower of these establishing the ventral margins of pigmentation on the trunk, below this the belly silvery-white, sometimes with a soft rosy flush.

Head colour similar to trunk, brownish with black markings, a distinct dark line across upper operculum, through eye and across snout to upper lip, a second line across mid-lower operculum and cheeks below eye to corner of mouth, below this, the head silvery white.

Fin membranes unpigmented, but fin rays with strong, irregular dark brown-black markings.

Males are distinctly darker, the lateral blotching evident in the females becoming consolidated to form a definite mid-lateral dark brown to black band.

In preservative grey-black, with paler grey areas, and belly white, marking patterns as in life.

Sexual dimorphism: sexes distinct although not markedly so. The pelvic fins in the male are much longer than those in the female (Table 1) and females grow much larger than males (Figure 3), but the chief difference is in the structure of the anal fin. This is, in part, evident from the data in Table 1, where figures show that the length of the anal fin base of the male is almost twice that of the female. The male anal fin is extensively modified, being sheathed with a series of greatly enlarged scales that originate adjacent to the anal fin base, and project ventrally to encase the proximal two-thirds of the fin, the distal third

Table 1 Morphometric variation in *Lepidogalaxias salamandroides* (figures given as % of denominations in ratios).

	Male				Female			
	Min.	**Mean**	**Max.**	**SD**	**Min.**	**Mean**	**Max.**	**SD**
Total length/standard length	115.3	120.65	125.0	2.95	113.9	119.71	124.1	3.42
Body depth at vent/standard length	13.2	15.24	17.7	1.42	11.6	12.75	13.9	0.78
Length of caudal peduncle/standard length	20.0	22.48	24.2	1.35	21.2	24.06	27.8	1.94
Depth of caudal peduncle/standard length	11.0	12.86	15.1	1.55	10.5	12.87	14.6	1.22
Depth of caudal peduncle/length of peduncle	50.0	57.01	65.5	5.73	46.1	54.24	63.6	4.52
Predorsal length/standard length	62.1	64.83	67.6	1.87	63.0	65.23	68.8	2.01
Preanal length/standard length	64.4	67.36	69.7	1.88	67.9	70.65	73.8	1.69
Predorsal length/preanal length	91.9	96.19	98.8	2.13	88.0	92.14	94.6	2.40
Length of dorsal fin base/standard length	4.2	4.91	7.3	0.74	4.0	5.50	6.8	0.91
Maximum length of dorsal fin/basal length	300.0	376.33	440.0	45.94	264.7	324.36	375.0	39.72
Length of anal fin base/standard length	11.8	13.54	17.7	1.04	6.3	7.44	8.1	0.65
Maximum length of anal fin/basal length	131.6	142.24	162.5	13.31	185.7	195.36	200.0	6.56
Pectoral fin length/pectoral pelvic length	52.9	60.81	69.2	5.15	49.0	57.32	63.0	4.71
Pelvic fin length/pelvic anal length	100.0	123.08	135.7	10.45	76.9	84.63	94.7	5.93
Prepelvic length/standard length	42.4	44.92	48.5	1.79	41.0	43.23	44.6	0.99
Pectoral pelvic length/standard length	20.0	23.31	25.0	1.50	20.7	22.53	25.0	1.30
Pelvic-anal length/standard length	21.9	23.26	25.8	1.10	25.7	27.96	30.5	1.53
Head length/standard length	17.7	21.24	24.2	2.06	20.1	22.11	24.1	1.20
Head width/head length	50.0	56.05	60.9	3.70	51.1	56.83	63.2	4.80
Head depth/head length	50.0	56.39	60.9	3.64	50.1	54.17	59.4	3.42
Snout length/head length	16.7	18.38	21.7	1.67	17.1	19.86	22.2	1.94
Postorbital head length/head length	56.0	62.40	69.6	5.28	57.1	61.63	65.2	2.59
Interorbital width/head length	13.3	15.46	20.0	2.37	13.2	16.75	20.5	2.36
Eye diameter/head length	23.1	26.32	32.1	2.34	19.6	22.42	25.0	1.70
Length of upper jaw/head length	28.0	34.68	39.1	3.43	31.1	34.76	37.5	2.18
Length of lower jaw/head length	28.0	25.47	34.8	2.07	29.7	33.10	36.8	2.02
Width of gape/head length	30.0	34.82	39.1	3.48	28.6	33.37	36.8	2.38
No. measured		10				10		

projecting back between the sheathing scales (Figure 4). Rosen (1974) has described extensive modification of the fin skeleton in this fin (Figure 5). He (p. 301) reported that the anal fin of 'the fully differentiated male always occurs strongly folded to the right or left in preserved specimens', and that 'Histological study of the entire anal fin region in *Lepidogalaxias* shows that the sperm duct opens into a sinus near the anal fin origin . . . bounded partly by the scale sheath and . . . continuous with a channel formed by the ventral edge of the scale sheath and the folded anal fin rays. This channel opens to the outside near the tip of the posterior rays of the fin two of which are bifurcated. Presumably the channel conveys sperm . . .'

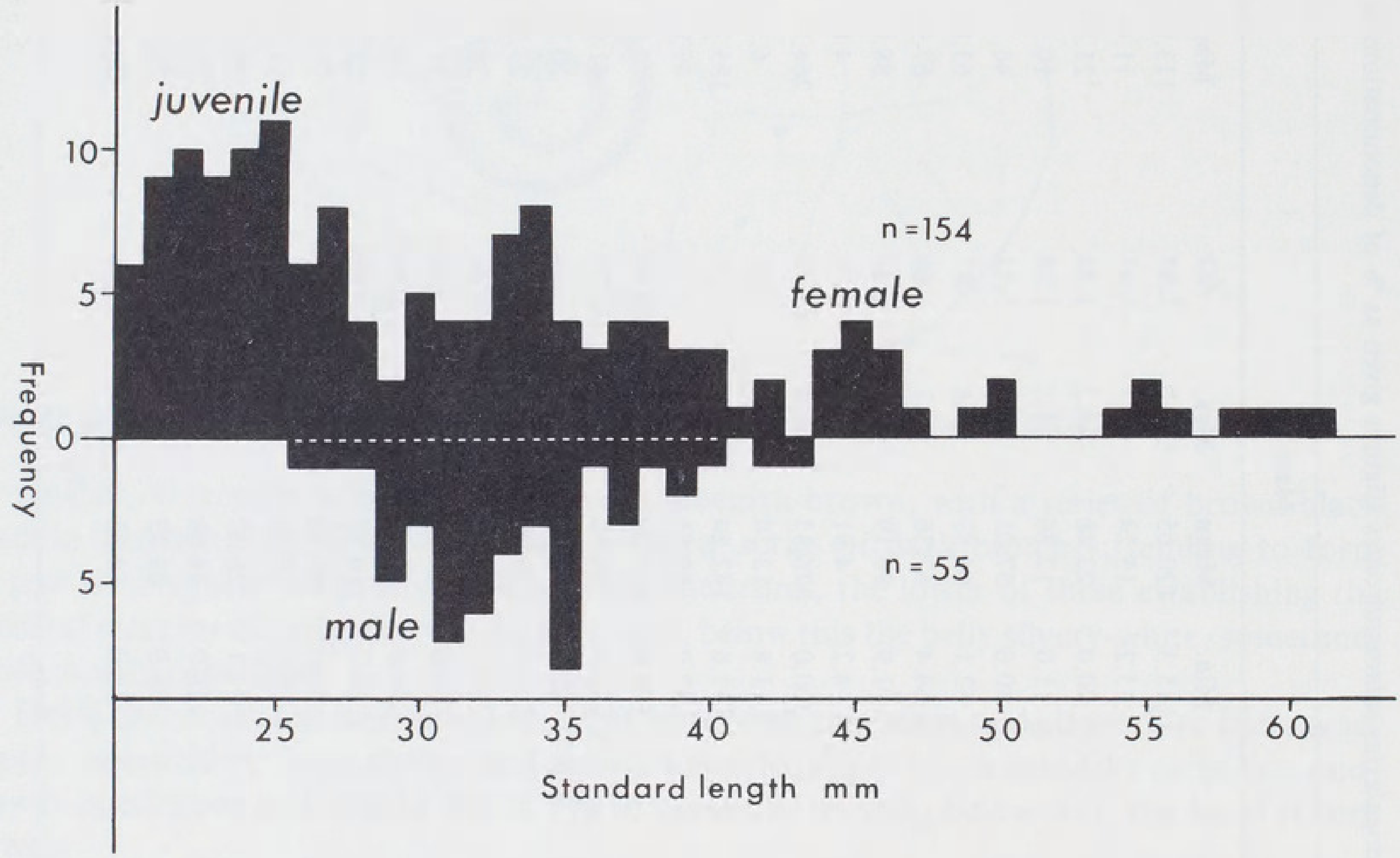

Figure 3 Size-frequency distribution of male and female *Lepidogalaxias salamandroides*.

So little is known about the natural history of this species that the significance of this structure in the male, and how it functions, remain obscure.

The female, in contrast, has a form of genital papilla that protrudes from the abdomen, adjacent to the vent and just in front of the unmodified anal fin.

Size: *Lepidogalaxias salamandroides* is known to reach 61.0 mm S.L. (70.5 mm T.L.), this being a large female from the Shannon River, 10 January 1982 (WAM P.27522-001). Allen (1982) reports it as 'Maximum size to about 5 cm SL, commonly to 3.5 cm SL', and this is in accord with the data we have (Figure 3). Males are smaller than females, the largest male measured in this study being 43 mm SL, most being 30-35 mm SL. Females were commonly about the same size, but much larger females were also present in the populations.

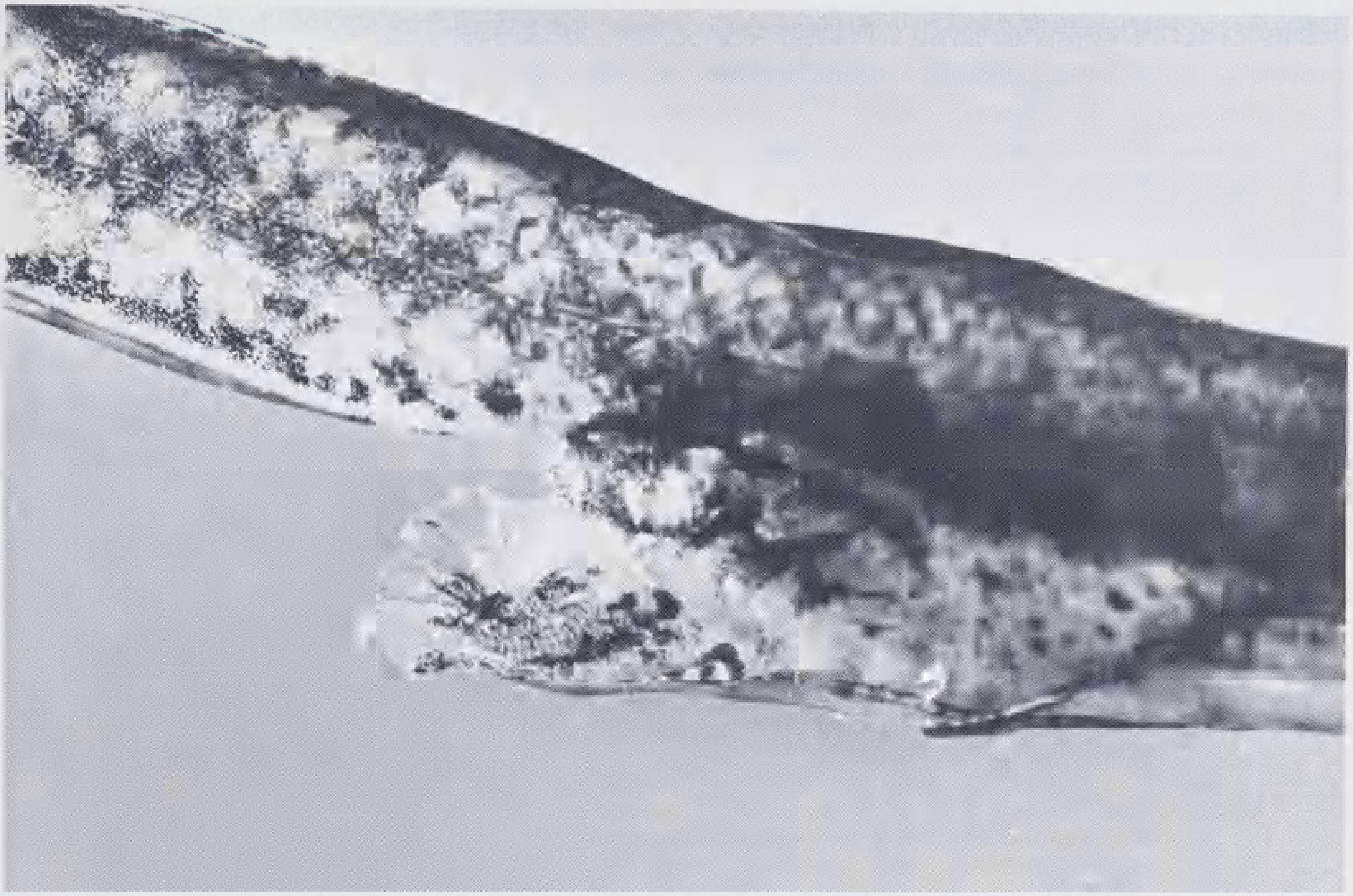

Figure 4 Anal fin of mature male *Lepidogalaxias salamandroides.*

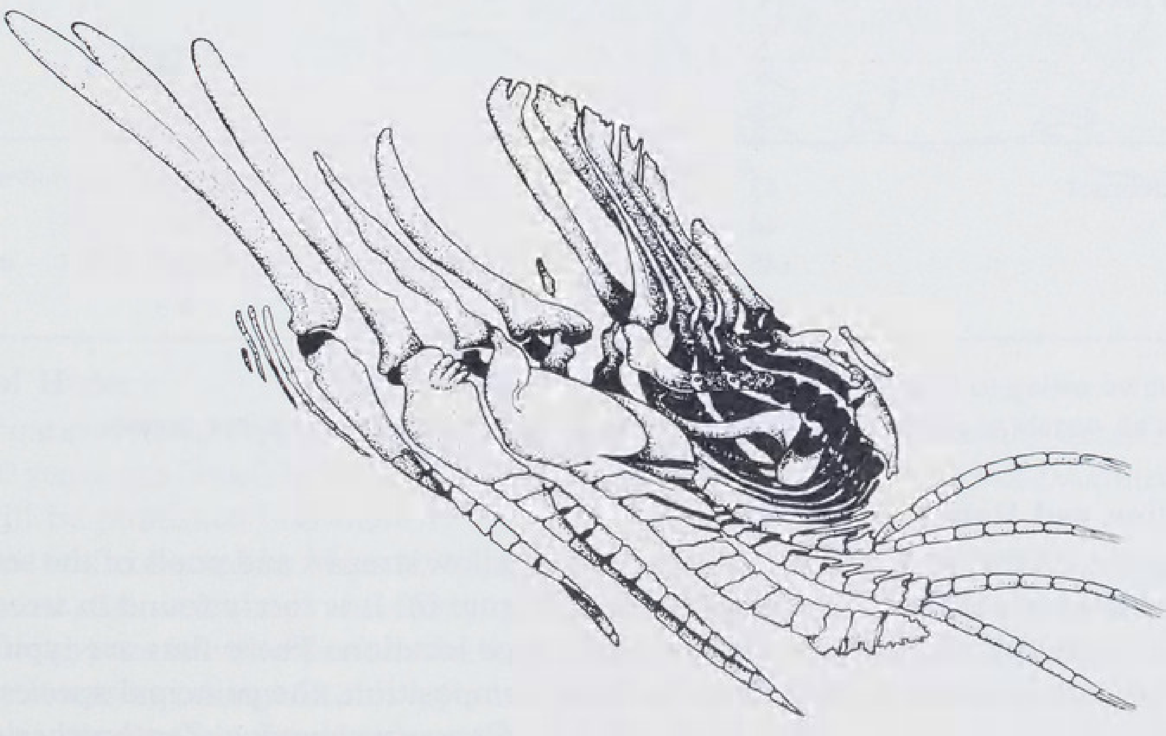

Figure 5 Structure of support of anal fin in male *Lepidogalaxias salamandroides* (from Rosen 1974).

Table 2 Meristic variation in *Lepidogalaxias salamandroides*

		Male		Female
Dorsal rays	0-5	1		1
	0-6	5		2
	0-7	-		1
	i-5	1		-
	i-6	3		1
	i-7	-		1
	ii-6	-		4
Anal rays	ii-11	-*		5
	ii-12	-		-
	iii-11	-		3
	iii-12	-		2
Caudal rays	12	8		7
	13	1		3
	14	1		
Pelvic rays	4	10		10
Pectoral rays	10	1		
	11	6		5
	12	3		5
Gill rakers	4			1
	5	3		3
	6	2		6
	7	1		
Vertebrae†	43		1	
	44		4	
	45		6	
	46		6	

* Not counted owing to highly modified character of anal fin in males.

† Includes all vertebrae with articular facets at both ends, a 'total count' is one greater.

Distribution and Habitat

L. salamandroides is found most commonly in shallow streams and pools of the southern acid peaty flats of southern Western Australia (Figure 6). It is rarely found in streams of the karri forest although these are listed as the type location. These flats are typified by acid, brown streams and a characteristic floral composition, the principal species being stunted *Eucalyptus marginata, Nuytsia floribunda, Casuarina humilus, Zanthorrhea preisii, Melaleuca, Beaufortia* and a *Banksia* spp. Allen (1982: 19) reported that the fish 'are generally associated with acidic water ranging in pH from about 4.5 to neutral'. There is no aquatic vegetation. Its range is an area of high rainfall, in excess of 1200 mm, and mild temperatures – summer maxima of 25-30°C and winter minima of 5-10°C. Rainfall is highly seasonal with the peak during winter and least during summer.

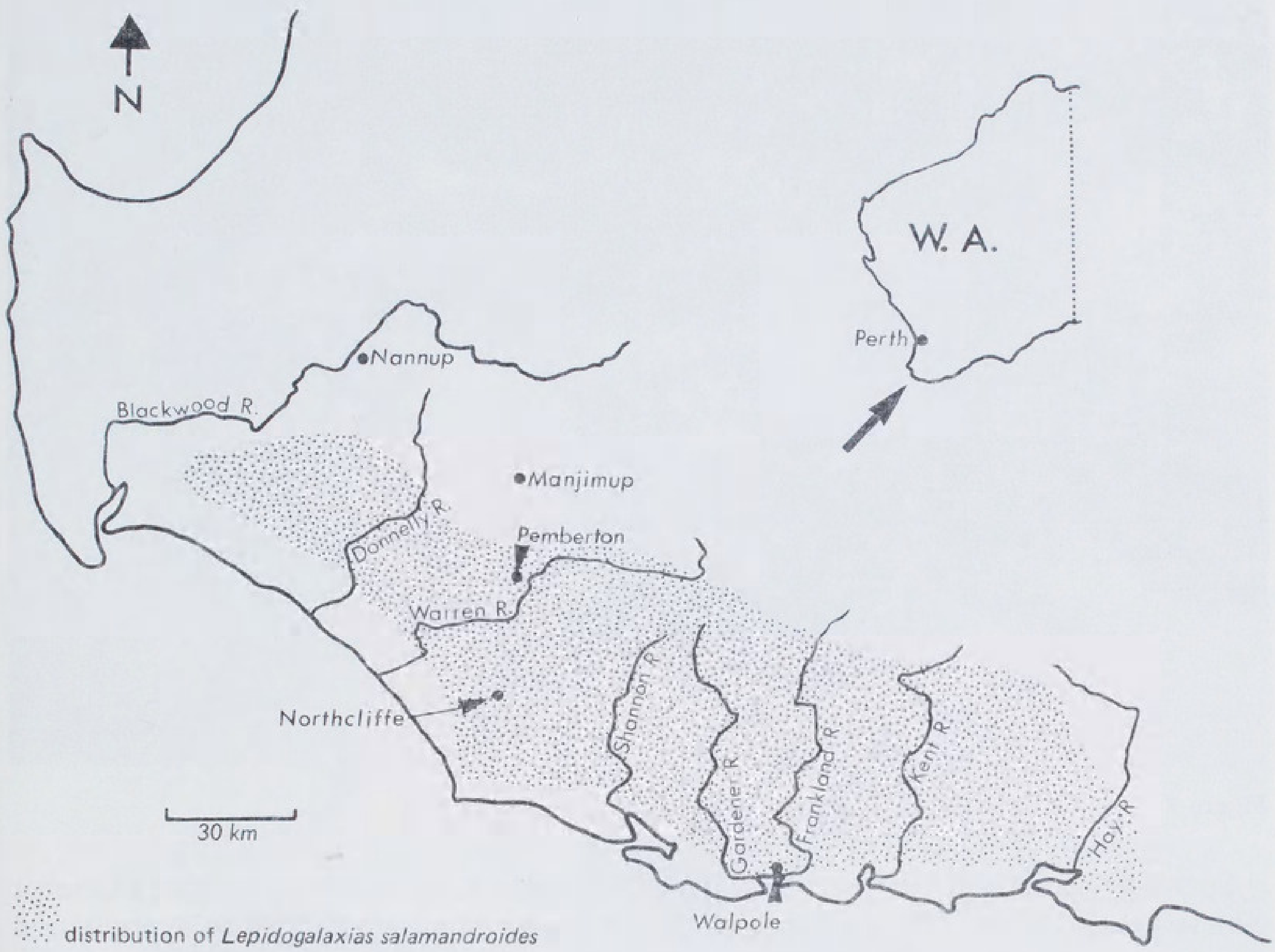

Figure 6 Distribution of *Lepidogalaxias* in Western Australia.

Natural History

The natural history of *L. salamandroides* is not well known. Since first described more than 20 years ago little has been reported although one of us (B.J.P.) has examined aspects that will be published elsewhere.

When first collected by Mees (1961) the fish were taken from a creek that was 'probably permanent, the water cool and fairly rapidly flowing . . . the creek bed was largely filled with *Eucalyptus* leaves especially in those places where the creek was slightly wider and deeper. It was by taking out this layer of leaves mixed with some mud, and carefully going through it that we obtained our specimens.' Allen (1982) stated 'this species is apparently capable of surviving drought periods by burrowing in mud or under damp leaves. Studies

(B.J.P.) show that the fish may burrow either head or tail first and construct a loose-pear-shaped burrow connected to the surface by a thin tube. They assume a U-shaped posture in the burrow (Figure 7).

Figure 7 *Lepidogalaxias salamandroides* as found aestivating.

Spawning occurs in the spring. Mees (1961) reported on a mature female caught in October with large eggs. Since this is approaching the dry season (summer) it might be hypothesized that the eggs are capable of surviving drought, and hatch when water returns in the autumn.

Population samples taken during the late autumn-early spring of 1981 reveal the juveniles from the spawning of the previous spring, plus a few adults, in the population in April. These juveniles move into the adult population as they mature during the winter. The males mature during their first year while the females delay maturity until the second.

The eyes are adnate, lacking a circum-orbital sulcus (Figure 8) and are covered by a secondary eyelid. This structure is presumably an adaptation to protect the eyes when burrowing in benthic detritis and when aestivating during periods of drought. Observations on behaviour in captivity reveal the ability of the fish to bend the 'neck' at a quite sharp angle either sideways and/or downwards (Figure 9). This behaviour is related to food search, the fish observing moving food items on the tank bottom, moving adjacent to them, and bending the head sideways and/or down to locate the items before engulfing them.

Frankenberg (1969: 116) refers to 'spaces between the anteriormost vertebrae' and these are evident in cleared and stained specimens between the exoccipital, the first and second vertebrae. Possibly the spacing of the vertebrae increases the flexibility of the anterior vertebral column, facilitating the bending of the head sideways or downwards referred to above.

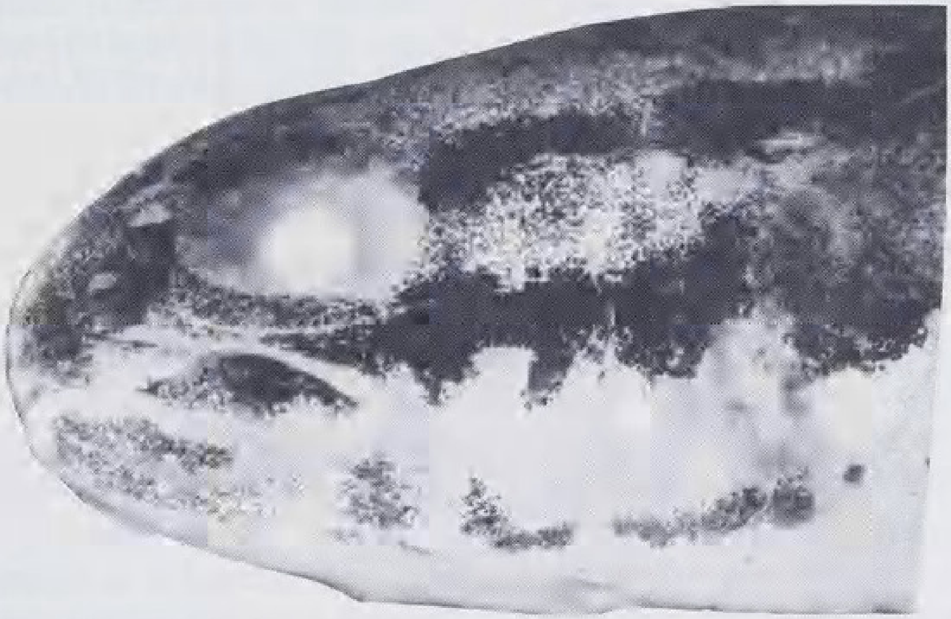

Figure 8 Eye of *Lepidogalaxias salamandroides* (note absence of circum-orbital sulcus).

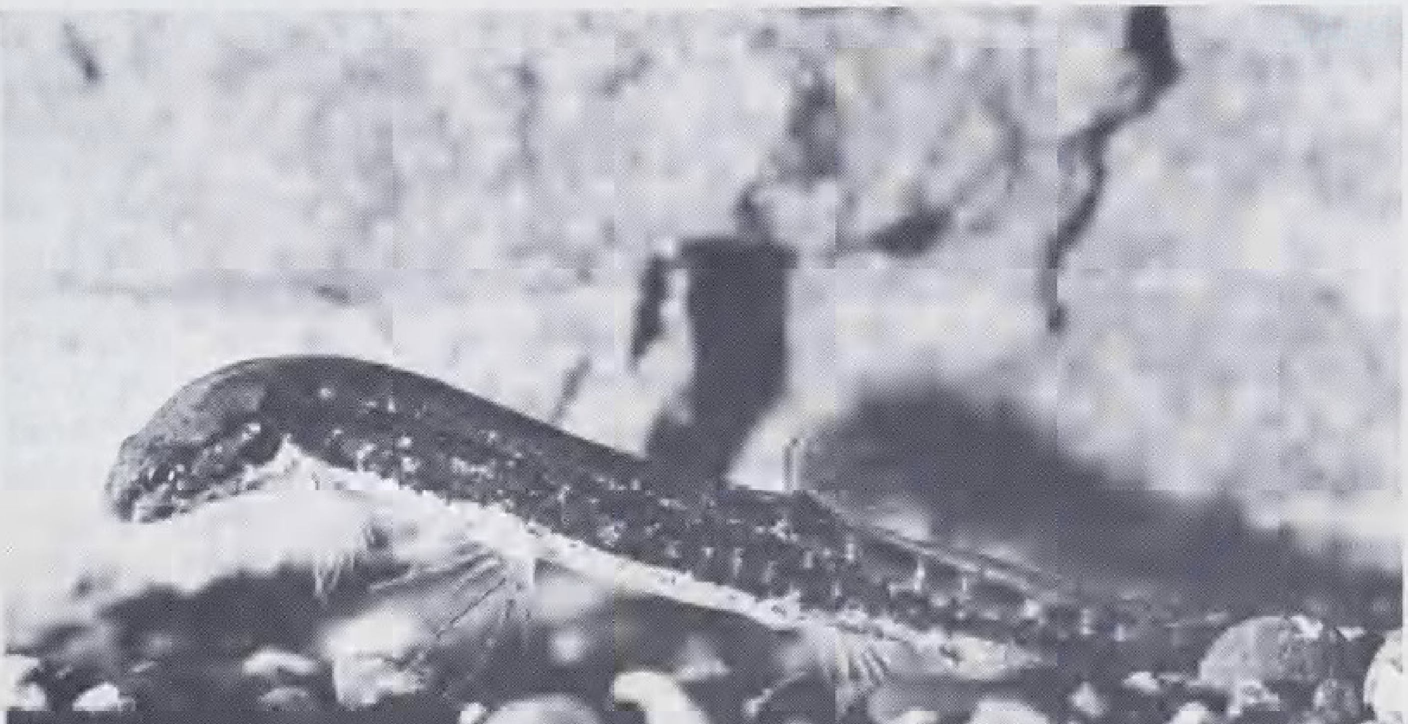

Figure 9 *Lepidogalaxias salamandroides* female (note elevated trunk perched on pelvic fins and distinct bend of neck).

Dissections of the eye failed to reveal the presence of the eye muscles that control eye movements in typical fish, and during observations of both mobile and anaesthetized live fish, no eye movements were noticed. The apparent inability of the eye to move is predictable inasmuch as the presence of the folded epidermis in the circum-ocular sulcus of typical fishes, but lacking in *Lepidogalaxias,* is what allows the eye to rotate in its socket.

Another interesting behaviour is the posture commonly adopted by the fish. The pelvic fins, which have greatly elongated central rays that are unconnected distally by membrane, are capable of rotating forwards so that the central rays point forward. *Lepidogalaxias* in captivity were commonly observed to raise the entire trunk up from the substrate resting on a tripod formed by the tail and the forward-rotated and outspread pelvic fins so that head was elevated at an angle of 30^0 or more and the pectoral fins hanging in space free from the substrate. This posture was commonly adopted during the search phase in feeding in captivity (Figure 9).

Much remains to be learned of the relationships and natural history of *Lepidogalaxias.* Apart from the fact that it belongs amongst the most primitive of protacanthopterygian fishes its relationships seem poorly defined. Ecologically, little is known. In spite of its small size and unspectacular appearance this is a species of importance to Australian natural history; attention should be given to increased knowledge and to ensuring that its habitats and populations are protected.

Material Examined

WAM P.4887 holotype female, 49 mm SL (60 mm TL): Tiny creek about 6 miles ENE of Shannon River, 34^{0}48′E, 116^{0}26′S; WAM P. 4888, 3 paratypes, collected with holotype; WAM P.13922-23: Drains, Mt Chudalup Road, Windy Harbour, W.A. 1 October 1962; WAM P.7449-50: Shannon River, upstream from type locality, W.A. 30 May 1964; WAM P.7447: North Road, Shannon River (type locality), W.A. 31 May 1964; WAM P.27691-001: Creeks and waterholes, W.A. 34^{0}50′S, 116^{0}50′E, 3 October 1975; WAM P.27522-001: Pool Shannon River, 12 km east on Preston Road, Northcliffe, W.A. 34^{0}38′S, 116^{0}21′E, 10 January 1982; AMS I.17127-001: Under bridge of Y Plain, 22 miles west of Walpole, W.A., 34^{0}55′S, 116^{0}33′E, March, 1973; AMS I.19614-001: Pools on Windy Harbour Road, d'Entrecasteaux Pt, W.A. 34°50′S, 116°00′E, 22 October 1976; AMNH 37674; 12.3 miles south of Northcliffe on Windy Harbour Road, W.A. 9 March, 1969; FRD Unregistered: 3 km north of Mt Chudalup, Windy Harbour 116°08′E, 34°28′S, on Windy Harbour Road; FRD Unregistered: 5 km west of Shannon River on Chesapeake Road, 116°28′E, 34°22′S.

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